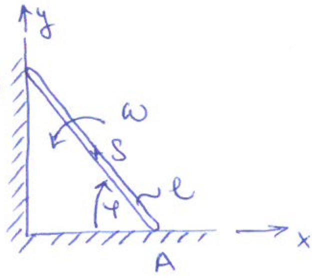
DINAMIKA – 4. gyakorlat

1.) Fal mellett lecsúszó létra



Adatok: $\varphi = 30^\circ$

$l = 4\,m$

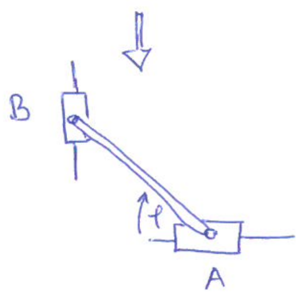
$\omega = 0{,}6 \ \frac{rad}{s}$

$\varepsilon = 0 \ \frac{rad}{s^2}$

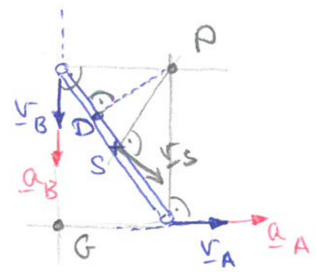
Feladatok:

P? G?

$\underline{v}_S$? D (legkisebb sebesség)



Megoldás:



$tg\,\alpha = \frac{\varepsilon}{\omega^2} = 0$

$\alpha = 0 \rightarrow G$

D: merőlegest állítunk, úgy lesz a legközelebbi a pont (legkisebb seb. ~ ami a legközelebb van P-hez)

Feladatok 2.:

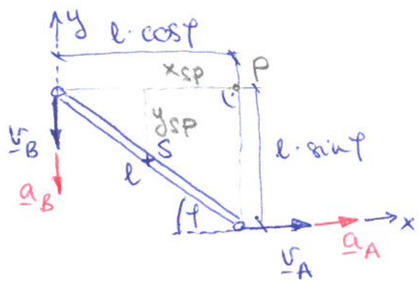
1.) pályagörbék sugarai: $\rho_A, \rho_B, \rho_S, \rho_D$?

2.) pólusgörbék egyenlete?

3.) pólusvándorlás sebessége?

Megoldás 2.:

1.)



Sebességek: $\underline{v}_A = \begin{bmatrix} v_A \\ 0 \\ 0 \end{bmatrix}$ $\quad \underline{v}_B = \begin{bmatrix} 0 \\ v_B \\ 0 \end{bmatrix}$

Gyorsulások: $\underline{a}_A = \begin{bmatrix} a_A \\ 0 \\ 0 \end{bmatrix}$ $\quad \underline{a}_B = \begin{bmatrix} 0 \\ a_B \\ 0 \end{bmatrix}$

Görbületi sugár: $\boxed{\rho = \frac{v^2}{a_n}}$

Tangenciális gyorsulás: párhuzamos a sebességgel.

$\underline{a}_A \parallel \underline{v}_A$ és $\underline{a}_B \parallel \underline{v}_B \rightarrow a_{An} = 0$; $a_{Bn} = 0$

$\rho_A = \frac{v_A^2}{0} = \infty \qquad \rho_B = \frac{v_B^2}{0} = \infty$!

(Később kiszámoljuk v_A-t, v_B-t pontosan!)

Számoljunk sebességeket!

$$\underline{v}_A = \underline{v}_B + \underline{\omega} \times \underline{r}_{BA} = \begin{bmatrix} 0 \\ v_B \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \omega \end{bmatrix} \times \begin{bmatrix} l \cdot \cos\varphi \\ -l \cdot \sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} l\,\omega \sin\varphi \\ v_B + l\,\omega \cos\varphi \\ 0 \end{bmatrix} = \underbrace{\begin{bmatrix} v_A \\ 0 \\ 0 \end{bmatrix}}_{\underline{v}_A}$$

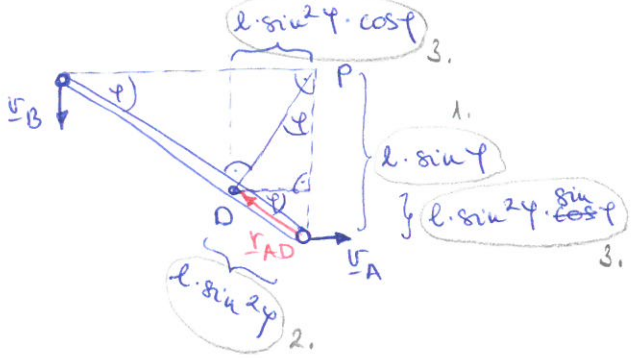
$$v_A = l\,\omega \sin\varphi = 1{,}2\ \frac{m}{s}$$

$$v_B = -l\,\omega \cos\varphi = -1{,}2 \cdot \sqrt{3}\ \frac{m}{s}$$

$$\underline{v}_S = \underline{v}_A + \underline{\omega} \times \underline{r}_{AS} = \begin{bmatrix} v_A \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \omega \end{bmatrix} \times \begin{bmatrix} -\frac{l}{2}\cos\varphi \\ \frac{l}{2}\sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} 0{,}6 \\ -0{,}6 \cdot \sqrt{3} \\ 0 \end{bmatrix} \left[\frac{m}{s}\right] = \frac{l}{2}\omega \begin{bmatrix} \sin\varphi \\ -\cos\varphi \\ 0 \end{bmatrix}$$

$$v_S = \frac{l}{2}\,\omega = 1{,}2\ \frac{m}{s}\quad \text{(nagysága)}$$

$$\underline{v}_D = \underline{v}_A + \underline{\omega} \times \underline{r}_{AD} = \begin{bmatrix} v_A \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \omega \end{bmatrix} \times \begin{bmatrix} -l \sin^2\varphi \cos\varphi \\ l \sin^2\varphi \cdot \sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} l \cdot \omega \cdot \sin\varphi \cdot \cos^2\varphi \\ -l\,\omega \cos\varphi \sin^2\varphi \\ 0 \end{bmatrix}$$



$$v_D = l\,\omega \sin\varphi \cos\varphi$$

$$\left(\underline{v}_D = \underbrace{l\,\omega \sin\varphi\cos\varphi}_{\text{nagyság}} \underbrace{\begin{bmatrix} \cos\varphi \\ -\sin\varphi \\ 0 \end{bmatrix}}_{\text{irány (nagysága 1)}} \right)$$

Póluspont megkeresése:

$$\underline{v}_P = \underline{v}_S + \underline{\omega} \times \underline{r}_{SP} = \begin{bmatrix} \frac{l}{2}\omega \sin\varphi \\ -\frac{l}{2}\omega \cos\varphi \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \omega \end{bmatrix} \times \begin{bmatrix} x_{SP} \\ y_{SP} \\ 0 \end{bmatrix} =$$

$$= \begin{bmatrix} \frac{l}{2}\omega \sin\varphi - y_{SP}\,\omega \\ -\frac{l}{2}\omega \cos\varphi + x_{SP}\,\omega \\ 0 \end{bmatrix} = \underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}}_{\underline{v}_P} \longrightarrow \left. \begin{aligned} y_{SP} &= \frac{l}{2}\sin\varphi \\ x_{SP} &= \frac{l}{2}\cos\varphi \end{aligned} \right\}$$

szerkesztéssel is ez jött ki! ü

Számoljunk gyorsulásokat!

$$\underline{a}_B = \underline{a}_A + \underbrace{\underline{\varepsilon} \times \underline{r}_{AB}}_{\underline{0}} - \omega^2 \underline{r}_{AB} = \begin{bmatrix} a_A \\ 0 \\ 0 \end{bmatrix} - \omega^2 \begin{bmatrix} -l\cos\varphi \\ l\sin\varphi \\ 0 \end{bmatrix} = \underbrace{\begin{bmatrix} 0 \\ a_B \\ 0 \end{bmatrix}}_{\underline{a}_B}$$

$$a_A = -\omega^2 l \cos\varphi$$

$$a_B = -l\omega^2 \sin\varphi$$

$$\underline{a}_S = \underline{a}_A + \underbrace{\underline{\varepsilon} \times \underline{r}_{AS}}_{\underline{0}} - \omega^2 \underline{r}_{AS} = \begin{bmatrix} a_A \\ 0 \\ 0 \end{bmatrix} - \omega^2 \begin{bmatrix} -\frac{l}{2}\cos\varphi \\ \frac{l}{2}\sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} -\omega^2 l\cos\varphi + \frac{l}{2}\omega^2\cos\varphi \\ -\frac{l}{2}\omega^2\sin\varphi \\ 0 \end{bmatrix} =$$

$$= \begin{bmatrix} -\frac{l}{2}\omega^2\cos\varphi \\ -\frac{l}{2}\omega^2\sin\varphi \\ 0 \end{bmatrix} \longrightarrow a_S = \underbrace{\frac{l}{2}\omega^2}_{\text{nagyság}}$$

$$\underline{a}_D = \underline{a}_A + \underbrace{\underline{\varepsilon} \times \underline{r}_{AD}}_{\underline{0}} - \omega^2 \underline{r}_{AD} = \begin{bmatrix} a_A \\ 0 \\ 0 \end{bmatrix} - \omega^2 \begin{bmatrix} -l\sin^2\varphi\cos\varphi \\ l\sin^2\varphi\sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} -\omega^2 l\cos^3\varphi \\ -\omega^2 l\sin^3\varphi \\ 0 \end{bmatrix}$$

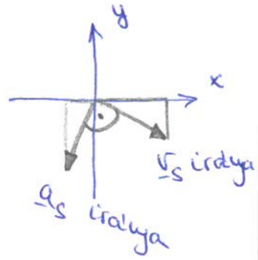
$$\underline{a}_P = \underline{a}_A + \underbrace{\underline{\varepsilon} \times \underline{r}_{AP}}_{\underline{0}} - \omega^2 \underline{r}_{AP} = \begin{bmatrix} a_A \\ 0 \\ 0 \end{bmatrix} - \omega^2 \begin{bmatrix} 0 \\ l\sin\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} -\omega^2 l\cos\varphi \\ -\omega^2 l\sin\varphi \\ 0 \end{bmatrix}$$

$$\boxed{\varrho_S = \frac{v_S^2}{a_{Sn}}}$$

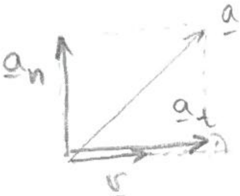
a_{Sn} ?

$$\underline{a}_S = \begin{bmatrix} -\frac{l}{2}\omega^2\cos\varphi \\ -\frac{l}{2}\omega^2\sin\varphi \\ 0 \end{bmatrix} = \frac{l}{2}\omega^2 \cdot \underbrace{\begin{bmatrix} -\cos\varphi \\ -\sin\varphi \\ 0 \end{bmatrix}}_{\text{egységvektor}}$$

$$\underline{v}_S = \begin{bmatrix} \frac{l}{2}\omega\sin\varphi \\ -\frac{l}{2}\omega\cos\varphi \\ 0 \end{bmatrix} = \frac{l}{2}\omega \underbrace{\begin{bmatrix} \sin\varphi \\ -\cos\varphi \\ 0 \end{bmatrix}}_{\text{e. vektor}}$$



Általánosan:



$\underline{a}_t \parallel \underline{v}$

$\underline{v}_S \perp \underline{a}_S$-re! $\longrightarrow$ $\underline{a}_S$-ben nincs tangenciális komponens $\rightarrow$ a_S nagysága lesz a_{Sn}

(Ha nem lennének $\perp$-ek $\rightarrow$ 1. gyakorlat, $\underline{a}_t$ számolás, $\underline{a}_n = \underline{a} - \underline{a}_t$)

$$a_{Sn} = \frac{\ell}{2}\omega^2 \rightarrow \varrho_S = \frac{\omega^2 \frac{\ell^2}{4}}{\omega^2 \cdot \frac{\ell}{2}} = \frac{\ell}{2} = \underline{\underline{2\ m}}$$

$$\boxed{\varrho_D = \frac{v_D^2}{a_{Dn}}}$$

$$\underline{v}_D = \underbrace{\ell\omega \sin\varphi \cos\varphi}_{\text{nagyság}} \underbrace{\begin{bmatrix} \cos\varphi \\ -\sin\varphi \\ 0 \end{bmatrix}}_{\text{irány}}$$

tangenciális gyorsulás iránya: $\underline{e}_t = \begin{bmatrix} \cos\varphi \\ -\sin\varphi \end{bmatrix}$

normális —"— : $\underline{e}_n = \begin{bmatrix} \sin\varphi \\ \cos\varphi \end{bmatrix}$

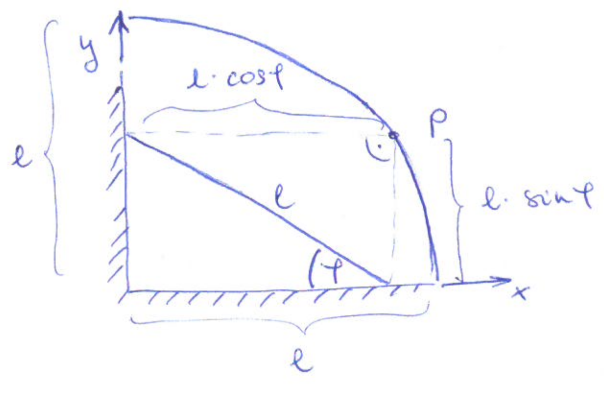
$$a_{Dn} = \underline{a}_D \cdot \underline{e}_n = \begin{bmatrix} -\omega^2\ell\cos^3\varphi \\ -\omega^2\ell\sin^3\varphi \\ 0 \end{bmatrix} \cdot \begin{bmatrix} \sin\varphi \\ \cos\varphi \\ 0 \end{bmatrix} =$$

$$= -\omega^2\ell\cos^3\varphi\sin\varphi - \omega^2\ell\sin^3\varphi\cos\varphi =$$

$$= -\omega^2\ell\cos\varphi\sin\varphi\underbrace{(\cos^2\varphi + \sin^2\varphi)}_{1} = -0{,}6235\ \frac{m}{s^2}$$

$$\varrho_D = \frac{v_D^2}{|a_{Dn}|} = \underline{\underline{1{,}732\ m}}$$

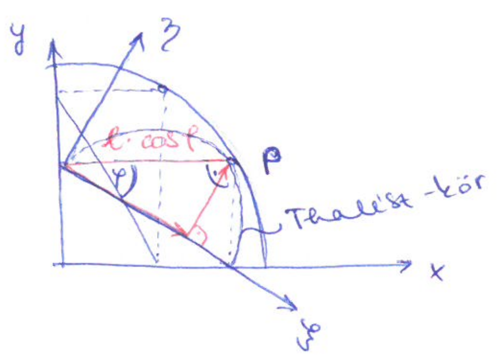
b) Póluságörbék egyenlete:



Álló póluságörbe: A póluspont geometriai helye az abszolút koord. rsz.-ben.

$$x_P = \ell\cos\varphi$$
$$y_P = \ell\sin\varphi$$
körequenlet

$$x_P^2 + y_P^2 = \ell^2 \quad (\text{sugár: } \ell)$$



Mozgó póluságörbe: A létrához képest a póluspont geometriai helye.

$$\xi_P = \ell \cdot \cos\varphi \cdot \cos\varphi = \ell\cos^2\varphi = \ell\,\frac{1+\cos 2\varphi}{2}$$

$$\eta_P = \ell\cos\varphi\sin\varphi = \ell\,\frac{\sin 2\varphi}{2}$$

Thalész-kör középpontja: $\boxed{S}$ Sugara: $\frac{l}{2}$

$$\left.\begin{aligned} \xi_p - \frac{l}{2} &= \frac{l}{2}\cos 2\varphi \\ \eta_p &= \frac{l}{2}\sin 2\varphi \end{aligned}\right\} \text{ S és P pont közötti vektor}$$

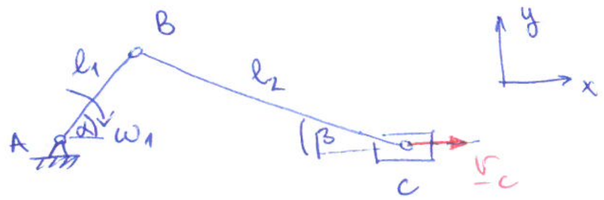
$$\left(\xi_p - \frac{l}{2}\right)^2 + \eta_p^{\,2} = \left(\frac{l}{2}\right)^2$$

c, Pólusvándorlás sebessége:

$$\underline{u} = \frac{\underline{\omega} \times \underline{a}_p}{\omega^2} \qquad \underline{\omega} \times \underline{a}_p = \begin{bmatrix} 0 \\ 0 \\ \omega \end{bmatrix} \times \begin{bmatrix} -\omega^2 l \cos\varphi \\ -\omega^2 l \sin\varphi \\ 0 \end{bmatrix} = -\omega^3 l \begin{bmatrix} -\sin\varphi \\ \cos\varphi \\ 0 \end{bmatrix}$$

$$\underline{u} = \omega l \begin{bmatrix} \sin\varphi \\ \cos\varphi \\ 0 \end{bmatrix} = \begin{bmatrix} 1{,}2 \\ -2{,}078 \\ 0 \end{bmatrix} \left[\frac{m}{s}\right]$$

2.) Forgattyús mechanizmus



Adatok:

l_1, l_2

$v_C = \text{áll.}$

$\alpha = 60°$

$\beta = 30°$

Feladatok:

1.) ω_1

2.) ω_2

~~3, Seb. ábra~~

4.) ε_1

5.) ε_2

~~6, gyorsulásábra~~

Megoldás: Amit tudunk: $\underline{v}_C = \begin{bmatrix} v_C \\ 0 \\ 0 \end{bmatrix}$ $\underline{a}_C = \underline{0}$ $\underline{v}_A = \underline{0}$ $\underline{a}_A = \underline{0}$

~ B pont rajta van (1) és (2)-n:

$$\underline{v}_B = \underbrace{\underline{v}_A}_{\underline{0}} + \underline{\omega}_1 \times \underline{r}_{AB} = \begin{bmatrix} 0 \\ 0 \\ \omega_1 \end{bmatrix} \times \begin{bmatrix} l_1 \cos\alpha \\ l_1 \sin\alpha \\ 0 \end{bmatrix} = l_1 \omega_1 \begin{bmatrix} -\sin\alpha \\ \cos\alpha \\ 0 \end{bmatrix}$$

$$\underline{v}_B = \underline{v}_C + \underline{\omega}_2 \times \underline{r}_{CB} = \begin{bmatrix} v_C \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \omega_2 \end{bmatrix} \times \begin{bmatrix} -l_2 \cos\beta \\ l_2 \sin\beta \\ 0 \end{bmatrix} = \begin{bmatrix} v_C - l_2 \omega_2 \sin\beta \\ l_2 \omega_2 \cos\beta \\ 0 \end{bmatrix}$$

2 egyenlet, 2 ismeretlen: ω_1, ω_2

$$l_1 \omega_1 \cos \cancel{\beta}^{\alpha} = l_2 \omega_2 \cos\beta \longrightarrow \omega_1 = \frac{l_2}{l_1} \frac{\cos\beta}{\cos\alpha} \omega_2$$

$$v_c - l_2 \sin\beta \cdot \omega_2 + l_2 \,\mathrm{tg}\,\alpha \cdot \cos\beta\, \omega_2 = 0 \longrightarrow \omega_2 = \frac{v_c}{l_2(\sin\beta - \mathrm{tg}\,\alpha \cdot \cos\beta)}$$

2.) $$\omega_2 = \frac{v_c}{2 l_2}$$

1.) $$\omega_1 = -\omega_2 \cdot \frac{l_2}{l_1} \sqrt{3} = -\frac{\sqrt{3}}{2} \frac{v_c}{l_1}$$

~ Gyorsulásállapot:

$$\underline{a}_B = \underbrace{\underline{a}_A}_{\underline{0}} + \underline{\varepsilon}_1 \times \underline{r}_{AB} - \omega_1^2 \underline{r}_{AB} = \begin{bmatrix} 0 \\ 0 \\ \varepsilon_1 \end{bmatrix} \times \begin{bmatrix} l_1 \cos\alpha \\ l_1 \sin\alpha \\ 0 \end{bmatrix} - \omega_1^2 \begin{bmatrix} l_1 \cos\alpha \\ l_1 \sin\alpha \\ 0 \end{bmatrix} =$$

$$= \begin{bmatrix} l_1(-\sin\alpha \cdot \varepsilon_1 - \omega_1^2 \cdot \cos\alpha) \\ l_1(\cos\alpha \cdot \varepsilon_1 - \omega_1^2 \cdot \sin\alpha) \\ 0 \end{bmatrix}$$

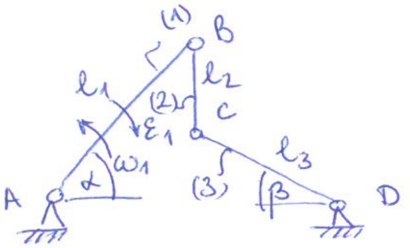
$$\underline{a}_B = \underbrace{\underline{a}_C}_{} + \underbrace{\underline{\varepsilon}_2}_{\begin{bmatrix} 0 \\ 0 \\ \varepsilon_2 \end{bmatrix}} \times \underline{r}_{CB} - \omega_2^2 \underline{r}_{CB} = \dots = \begin{bmatrix} l_2(-\sin\beta \cdot \varepsilon_2 - \omega_2^2 \cos\beta) \\ l_2(-\cos\beta \cdot \varepsilon_2 - \omega_2^2 \sin\beta) \\ 0 \end{bmatrix}$$

2 egyenlet, 2 ismeretlen: $\longrightarrow \dots \longrightarrow$

$$\varepsilon_1 = \frac{4 l_1 l_2 \omega_2^2 + 3 v_c^2 \cos(\alpha+\beta)}{4 l_1^2 \sin(\alpha+\beta)}$$

$$\varepsilon_2 = \omega_2^2 \frac{1}{\mathrm{tg}(\alpha+\beta)} + \frac{3}{4} \frac{v_c^2}{l_1 l_2 \sin(\alpha+\beta)}$$

3.) Négycsuklós mechanizmus



Adatok:

$l_1 = 0{,}6\ m$

$l_2 = 0{,}3\ m$

$l_3 = 0{,}3\ m$

$\omega_1 = 3{,}5\ \frac{rad}{s}$

$\varepsilon_1 = 20\ \frac{rad}{s^2}$

$\alpha = 60°$

$\beta = 45°$

Kérdések:

a, seb. állapot?

$v_B,\ \omega_2$

$v_C,\ \omega_3$

P_2

b, gyorsulás állapot?

$a_B,\ \varepsilon_2$

$a_C,\ \varepsilon_3$

G_2

Megoldás:

a, ~ Álló pontok: $\underline{v}_A = \underline{0}$

$\underline{v}_D = \underline{0}$

~ $\underline{v}_B = \underbrace{\underline{v}_A}_{\underline{0}} + \underline{\omega}_1 \times \underline{r}_{AB} = \begin{bmatrix} 0 \\ 0 \\ \omega_1 \end{bmatrix} \times \begin{bmatrix} l_1 \cos\alpha \\ l_1 \sin\alpha \\ 0 \end{bmatrix} = \omega_1 l_1 \begin{bmatrix} -\sin\alpha \\ \cos\alpha \\ 0 \end{bmatrix}$

~ C pont rajta van (2)-n, (3)-n:

$$\left.\begin{aligned} &\underline{v}_C = \underline{v}_B + \underbrace{\underline{\omega}_2 \times \underline{r}_{BC}}_{\begin{bmatrix} 0 \\ 0 \\ \omega_2 \end{bmatrix} \times \begin{bmatrix} 0 \\ -l_2 \\ 0 \end{bmatrix}} = \begin{bmatrix} -\omega_1 l_1 \sin\alpha + l_2 \omega_2 \\ \omega_1 l_1 \cos\alpha \\ 0 \end{bmatrix} \\ &\underline{v}_C = \underbrace{\underline{v}_D}_{\underline{0}} + \underline{\omega}_3 \times \underline{r}_{DC} = \begin{bmatrix} 0 \\ 0 \\ \omega_3 \end{bmatrix} \times \begin{bmatrix} -l_3 \cos\beta \\ l_3 \sin\beta \\ 0 \end{bmatrix} = -l_3 \omega_3 \begin{bmatrix} \sin\beta \\ \cos\beta \\ 0 \end{bmatrix} \end{aligned}\right\} =$$

2 egyenlet, 2 ismeretlen (ω_2, ω_3):

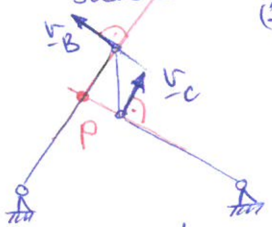
$$\omega_1 l_1 \cos\alpha = -l_3 \omega_3 \cos\beta$$

$$\omega_3 = -\omega_1 \cdot \frac{l_1}{l_3} \frac{\cos\alpha}{\cos\beta} = -4{,}95\ \frac{rad}{s}$$

$$\omega_2 = \frac{l_1}{l_2} \omega_1 \sin\alpha - \frac{l_3}{l_2} \omega_3 \sin\beta = 9{,}56\ \frac{rad}{s}$$

$\longrightarrow$ $\underline{v}_C = \begin{bmatrix} 1{,}05 \\ 1{,}05 \\ 0 \end{bmatrix} \left[\frac{m}{s}\right]$ $\quad$ $\underline{v}_B = \begin{bmatrix} -1{,}82 \\ 1{,}05 \\ 0 \end{bmatrix} \left[\frac{m}{s}\right]$

Szemlélet alapján (2) pólusa:



$\underline{r}_{BP} = \frac{1}{\omega_2^2} (\underline{\omega}_2 \times \underline{v}_B) = \ldots$

b) ~ Álló pontok: $\underline{a}_A = \underline{0}$, $\underline{a}_D = \underline{0}$; ε_1 ✓

~ $\underline{a}_B = \underbrace{\underline{a}_A}_{\underline{0}} + \underbrace{\underline{\varepsilon}_1}_{\begin{bmatrix} 0 \\ 0 \\ \varepsilon_1 \end{bmatrix}} \times \underline{r}_{AB} - \omega_1^2 \underline{r}_{AB} = \dots = \begin{bmatrix} 6,717 \\ -12,365 \\ 0 \end{bmatrix} \left[\frac{m}{s^2}\right] = \begin{bmatrix} a_{Bx} \\ a_{By} \\ 0 \end{bmatrix}$

$\varepsilon_1 = -20 \frac{rad}{s^2}$ Negatív, a rajz miatt!

~ C pont gyorsulása kétféleképpen:

$$\underline{a}_C = \underline{a}_B + \underline{\varepsilon}_2 \times \underline{r}_{BC} - \omega_2^2 \underline{r}_{BC} = \begin{bmatrix} a_{Bx} \\ a_{By} \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \varepsilon_2 \end{bmatrix} \times \begin{bmatrix} 0 \\ -l_2 \\ 0 \end{bmatrix} - \omega_2^2 \begin{bmatrix} 0 \\ -l_2 \\ 0 \end{bmatrix} =$$

$$= \begin{bmatrix} a_{Bx} + l_2 \varepsilon_2 \\ a_{By} + \omega_2^2 l_2 \\ 0 \end{bmatrix}$$

$$\underline{a}_C = \underbrace{\underline{a}_D}_{\underline{0}} + \underline{\varepsilon}_3 \times \underline{r}_{DC} - \omega_3^2 \underline{r}_{DC} = \begin{bmatrix} 0 \\ 0 \\ \varepsilon_3 \end{bmatrix} \times \begin{bmatrix} -l_3 \cos\beta \\ l_3 \sin\beta \\ 0 \end{bmatrix} - \omega_3^2 \begin{bmatrix} -l_3 \cos\beta \\ l_3 \sin\beta \\ 0 \end{bmatrix}$$

2 egyenlet, 2 ismeretlen: $\varepsilon_2, \varepsilon_3$

(HF) kiszámolni, eredmény: $\varepsilon_3 = -95,46 \frac{rad}{s^2}$

$\varepsilon_2 = 62,43 \frac{rad}{s^2}$

$\longrightarrow \underline{a}_C = \begin{bmatrix} 25,45 \\ 15,05 \\ 0 \end{bmatrix} \left[\frac{m}{s^2}\right]$

~ Gyorsuláspólus helye:

$$\underbrace{\underline{a}_G}_{\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}} = \underline{a}_B + \underline{\varepsilon}_2 \times \underline{r}_{GB} - \omega_2^2 \underline{r}_{GB} = \begin{bmatrix} a_{Bx} \\ a_{By} \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \varepsilon_2 \end{bmatrix} \times \begin{bmatrix} r_{GBx} \\ r_{GBy} \\ 0 \end{bmatrix} - \omega_2^2 \begin{bmatrix} r_{GBx} \\ r_{GBy} \\ 0 \end{bmatrix}$$

$\hookrightarrow 0 = a_{Bx} - \varepsilon_2 r_{GBy} - \omega_2^2 r_{GBx} \quad / \cdot \varepsilon_2$

$r_{GBx} = 0,1131 \text{ m}$

$+ \quad 0 = a_{By} + \varepsilon_2 r_{GBx} - \omega_2^2 r_{GBy} \quad / \cdot \omega_2^2$

$0 = \varepsilon_2 a_{Bx} + \omega_2^2 a_{By} - \varepsilon_2^2 r_{GBy} - \omega_2^4 r_{GBy} \rightarrow r_{GBy} = -0,058 \text{ m}$